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DESCRIPTION OF THE LARVA AND FEMALE OF *PYCNOPSYCHE FLAVATA* (BANKS) WITH COMPARATIVE NOTES ON THE ECOLOGY OF *P. FLAVATA* AND *P. GENTILIS* (MCLACHLAN) (TRICHOPTERA: LIMNEPHILIDAE)

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Abstract.—The larva and female of *Pycnopsyche flavata* (Banks) are described and figured for the first time. Ecological notes are provided for sympatric populations of *P. flavata* and *P. gentilis* (McLachlan). The highly variable morphology of *P. gentilis* larvae throughout the range of the species is discussed.

Members of the genus *Pycnopsyche* are of widespread and common occurrence throughout eastern North America. Larvae have been described for only six of the presently recognized 16 species in the genus (Flint, 1960). Reared material and/or metamorphotypes are available for *P. subfasciata* (Say) (Vorhies, 1909; Flint, 1960; G. B. Wiggins, personal communication) and *P. sonso* (Milne) (Flint, 1960); however, no specific characters for their identification have yet been elucidated.

The known distribution of *P. flavata* (Banks) is restricted to the mountains of western North Carolina, southwestern Virginia (C. R. Parker, personal communication), eastern Tennessee, northwestern South Carolina (J. C. Morse, personal communication), and northern Georgia. Collections of *P. flavata* larvae in Tennessee and North Carolina indicate a fairly specialized habitat preference.

Herein is described the larva of *P. flavata* with notes on its ecology obtained from year-round collections at a site in Tennessee. Because of the close morphological and behavioral similarity and frequent sympatric occurrence of *P. flavata* and *P. gentilis* (McLachlan), information on their life history in the southern Appalachians and on the variability of certain characters of *P. gentilis* larvae from five localities in eastern North America is also included. The female of *P. flavata* is described and figured for the first time.

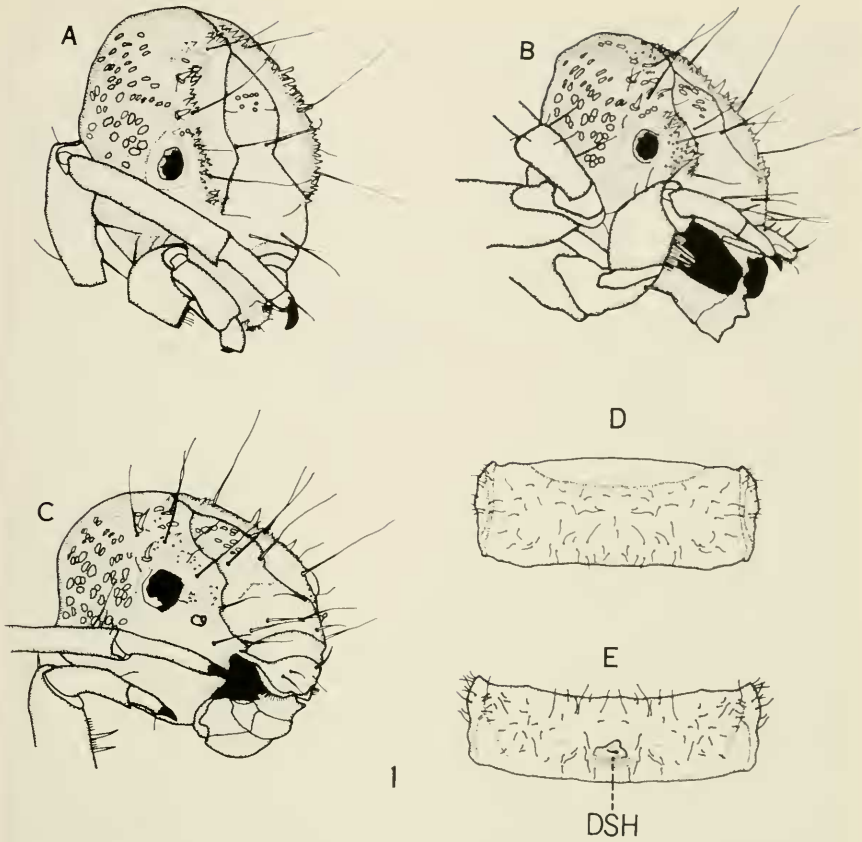

Fig. 1. Larvae of *Pycnopsyche flavata* and *P. gentilis*. A, Head of *P. flavata*. B, Head of southern *P. gentilis*. C, Head of northern *P. gentilis*. D, Dorsal view of first abdominal segment of *P. gentilis*. E, Dorsal view of first abdominal segment of *P. flavata*. DSH = dorsal spacing hump. Camera lucida drawings.

Materials and Methods

Collections of *P. flavata* larvae were first made in December 1977 in the Tellico Wildlife Management Area of the Cherokee National Forest, Monroe Co., Tennessee. Light trap samples of adults were obtained in July 1978, and pupae and larvae were brought back for rearing. Specimens were reared in aluminum window-screen envelopes partially submerged in a spring seep. Ten collections of larvae and/or pupae were made on an approximately monthly basis between July 1978 and June 1979. Additional larvae and pupae were obtained for rearing in June 1979. In all, 18 pupae and larvae were

reared for association purposes. An additional reared specimen was also discovered in some unidentified material borrowed from the Illinois Natural History Survey.

The description of the larva of *P. flavata* is based on 11 fifth-instar larvae from the Tellico site. Numerous other larvae from several localities were examined for much of the additional information in this paper. Larval instar determinations for *P. flavata* and *P. gentilis* were made using the method of approximate head widths (Dyar, 1890; Mackay, 1978). The notes on variation in *P. gentilis* were obtained from a study of 9 to 10 larvae from each of five localities including Essex Co., N.Y., Westmoreland Co., Pa., Bath Co., Va., Monroe Co., Tenn., and Morgan Co., Tenn. The larval description follows the format of Flint (1960) who provided a comparative account of *Pycnopsyche* larvae. The description of the female is based on 8 adults from Tennessee and North Carolina.

Description of Final Instar Larva of *Pycnopsyche flavata*

Length, 19.8–24.8 mm. Maximum width, 3–4 mm. *Head:* Yellowish brown. Muscle scars with dark borders on frons and posterior portion of genae. Front of head distinctly flattened with ridge of spines arcing from eye to eye. All 18 major setae present. Setae 13 and 16 flat and bladelike. Seta 16 on ridge of head appearing as member of arcuate band of spines. Setae 1 and 4 hyaline and appressed. Setae 6, 10, 11, and 12 light colored and cryptic. Seta 18 small and not obvious. Head width, 1.7–2.1 mm. *Thorax:* Pronotum yellowish brown with a series of spines on anterior edge and spinelike and hairlike setae dorsally. Mesonotum yellowish brown with spinelike and hairlike setae dorsally. Muscle scars present on pro- and mesonotum. Metanotum with Sa1, Sa2, and Sa3 sclerites. Metanotal Sa1 sclerites unfused. Setae present on membrane of metanotum. Legs yellowish brown. Prothoracic leg with 2 major spinelike setae ventrally on femur. Femora of meso- and metathoracic legs each with 2 major hairlike setae on ventral ridge. *Abdomen:* First segment with lateral spacing humps and remnants of dorsal spacing hump. Elongate sclerite present at posterior of each lateral hump. Dorsum (Sa1 + Sa2 areas) of 1st segment with 42–54 setae on either side of dorsal hump. Venter (Sa1 area) of 1st segment with 20–31 setae on either side. Sa2 sclerites on venter of 1st segment with 4–9 setae each. Eighth segment with 9–14 setae posteriorly on dorsum. Dorsal sclerite of 9th segment with 10–15 setae. *Gills:* Dorsal, II 0,1; III 1,1; IV 1,1; V 1,0-1; VI 0-1,0. Dorso-lateral, III 1,0; IV 0-1,0. Ventrolateral, II 0,1; III 0,0-1. Ventral, II 0,0-1; III 1,1; IV 1,1; V 1,1; VI 1,1; VII 1,1.

Diagnosis.—Of the known larvae of *Pycnopsyche*, that of *P. flavata* bears closest resemblance to that of *P. gentilis*. The larvae of both species possess bladelike 13th and 16th head setae. In *P. gentilis* both seta 13 and 16 are located on the curvature of the genae distinctly separate from other setae

Fig. 2. *Pycnopsyche flavata* larva showing placement of setae 13 and 16. 76×. SEM photograph.

and spines of the head (Figs. 1B, C; 3, 4). In *P. flavata* seta 16 is located in close apposition to an arcuate band of spines extending from eye to eye (Figs. 1A, 2). In addition, the head of *P. flavata* is distinctly flattened anteriorly. The head of *P. gentilis*, although often with a band of spines, displays a gradual rounding both laterally and dorsally. Finally, *P. gentilis* larvae lack a dorsal spacing hump on the 1st abdominal segment while *P. flavata* larvae possess at least the remnants of such a hump (Fig. 1D, E).

Description of Female of *Pycnopsyche flavata*

Length of forewing, 18–21 mm. Pale orange to tan. Forewing with a slight darkening along cord from R_5 to M_2 and with M-vein just proximal to cord, pale. Spur formula, 1-3-4. Opening of abdominal scent gland on anterolateral portion of 5th sternum. *Genitalia*. (Fig. 5): Segment IX in lateral view extended posteriad to sharp point dorsally, narrowed medially and widened and rounded ventrally. Dorsal IX with central concavity when viewed obliquely. Segment IX narrowed, rounded and tonguelike with median notch posteriorly in dorsal view. Ventral IX produced into cercus-like lobes. Dorsal X short and indistinct, slightly visible in dorsal view. Ventral X produced posteriorly into long, sclerotized scoop. Supragenital plate (SG.P.) membranous and not produced in lateral view. Vulvar scale (V.S.) produced to sharp point in lateral view, trilobed with central lobe mucronate viewed ventrally. Patches of setae on posterior VII and lateral to V.S. on VIII.

Diagnosis.—*Pycnopsyche flavata* is a member of the *divergens* group of Schmid (1955). Within this group the closest relative of *P. flavata* is *P. gentilis*. The female of *P. flavata* differs from that of *P. gentilis* mainly in the greater development of segment X. In *P. flavata* ventral X extends well beyond dorsal IX in lateral view. In *P. gentilis* ventral X extends at most even with dorsal IX and is often shorter.

Variation in the Larvae of *P. gentilis*

Although in all known instances the larvae of *P. gentilis* are readily distinguishable from those of *P. flavata*, a sizeable amount of variation is evident in *P. gentilis* from different localities. As previously reported by Flint (1960) the southern larvae of *P. gentilis* (Fig. 1B) display a much greater development of head spination than do the northern larvae (Fig. 1C), making them strikingly similar to the larvae of *P. flavata* (Fig. 1A). In this study, larvae from northern New York State were found to show extremely sparse spicule development. Those from southern Pennsylvania and southward, however, show considerably greater spicule development. Because of the difficulty of quantifying such a character, no attempt was made to determine if the variation is clinal. In addition, significant mean differences were shown to occur among localities in dorsal (Sa1 + Sa2) and ventral

Fig. 3. *Pycnopsyche gentilis* larva, southern, showing placement of setae 13 and 16. 76×. SEM photograph.

(Sa1) setal counts of the first abdominal segment ($P > F = .01$). Gill formulas also showed a degree of variability (mostly on the posterior segments), for the most part showing a greater development of gills than reported by Flint (1960).

Recently, it was brought to the author's attention that certain populations of *P. gentilis* adults have males with aedeagal titillators strikingly different from those of typical *P. gentilis* (D. A. Etnier, personal communication). Further study has revealed variability in tibial spur counts both among and within localities of *P. gentilis*, most of the males with the unique titillators having 1-2-4 spur formulas as opposed to the typical 1-3-4. Unfortunately, the 1-2-4 spur formulas are not restricted to the *P. gentilis* with the unique titillators and further work will be necessary to clarify the significance of this variability.

Notes on the Life History and Ecology of *P. flavata* and *P. gentilis*

Habitat.—The larvae of *P. flavata* are restricted to a rather specific habitat type in the southern Appalachians. Collections in North Carolina and Tennessee show that the larvae are most often found in the headwater areas of streams, typically at elevations near or above 1000 m. Within this habitat *P. flavata* larvae prefer spring heads where the water is slow moving and shallow (ca. 2–5 cm), although they may be found quite commonly in larger streams earlier in their development. Within their range, the larvae of *P. flavata* are nearly always found to occur sympatrically with the larvae of *P. gentilis* and occasional collections have also yielded both *P. sonso* and *P. luculenta* (Betten) at the same locality.

Case structure.—Monthly collections during 1978 and 1979 at sites in eastern Tennessee indicate that early instar *P. gentilis* and *P. flavata* may construct triangular leaf cases as reported by Flint (1960) and Mackay (1972) or may instead by-pass these and immediately begin construction of stone cases. The later instar cases of both species are cylindrical and constructed of small stones. The type and particular size of stones used in the case appear to be more a function of availability than of specific preference, as indicated by variability among collection sites, especially in *P. gentilis*. Although selection for specific substrate sizes in case building may occur within locality (Mackay, 1977) my observations suggest that this is not a species-wide phenomenon.

Larval development.—The third-, fourth-, and fifth-instars were readily identifiable for both species. Mean head widths of comparable instars of *P. flavata* and *P. gentilis* differ noticeably, those of *P. gentilis* being somewhat smaller. A comparison of data for *P. gentilis* with that of Mackay (1972) indicates a slightly smaller head width for the southern larvae. Third-instar *P. flavata* show a mean head width of .82 mm (range: .71–.87 mm; mode:

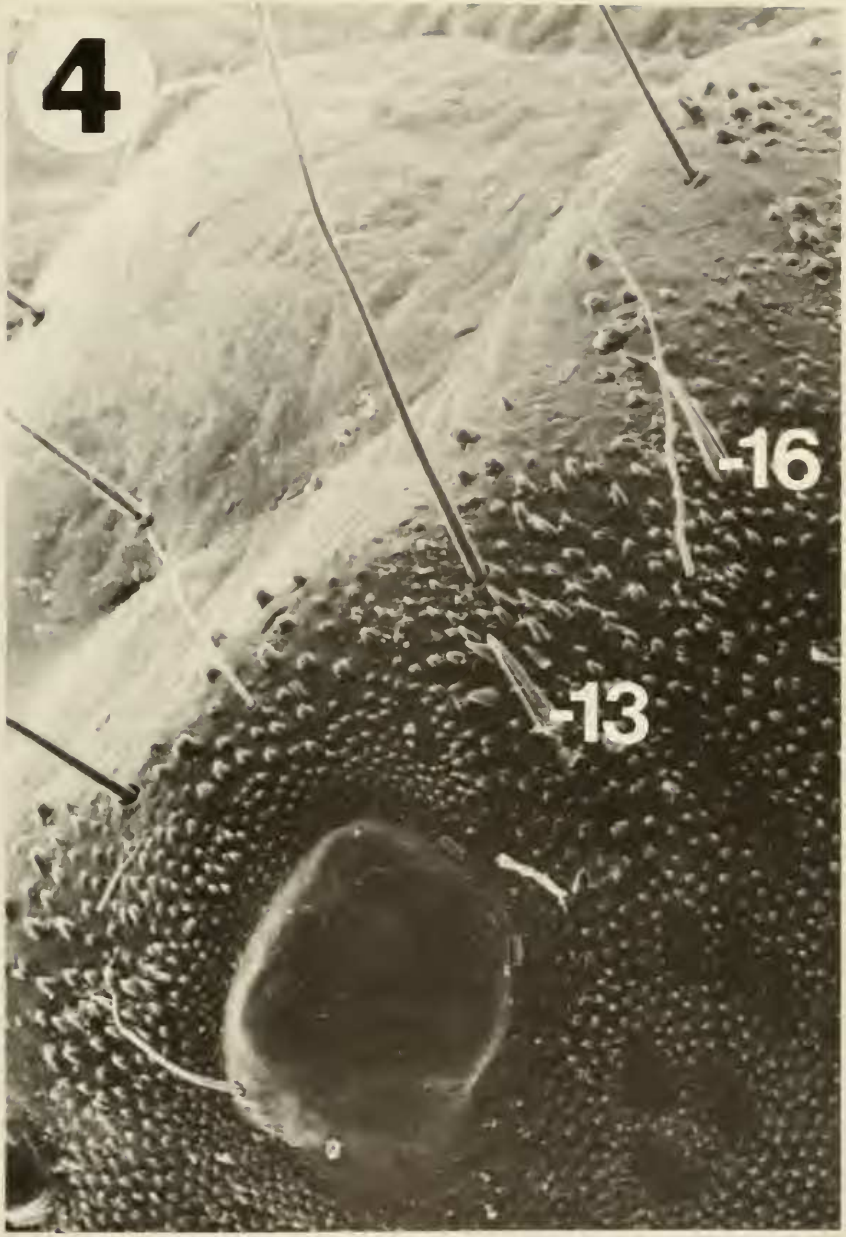

Fig. 4. Northern *Pycnopsyche gentilis* larva showing placement of setae 13 and 16. 76×. SEM photograph.

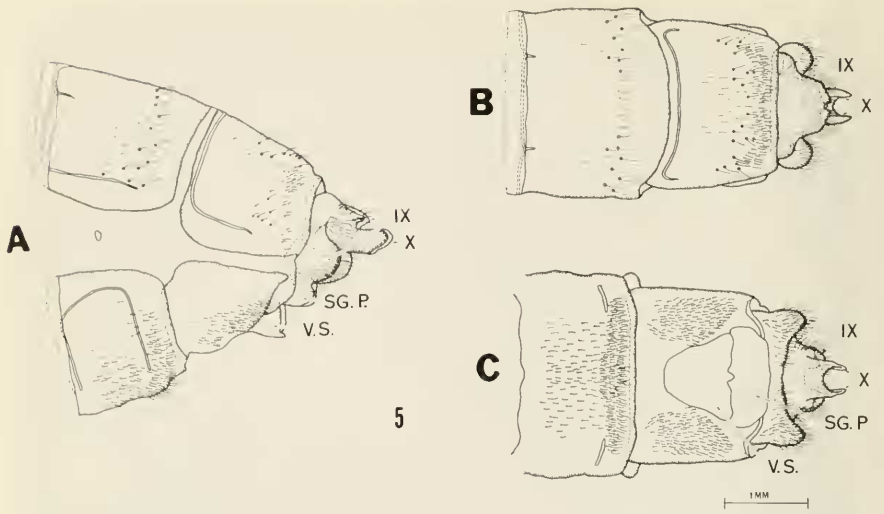

Fig. 5. Female genitalia of *Pycnopsyche flavata*. A, Lateral view. B, Dorsal view. C, Ventral view. SG.P. = supragenital plate; V.S. = vulvar scale. Camera lucida drawings.

.74 mm; $n = 66$) vs. a mean of .76 mm (range: .71–.90 mm; mode: .74 mm; $n = 44$) in *P. gentilis*. Mean head widths for fourth-instar larvae are 1.25 mm (range: 1.15–1.36 mm; mode: 1.26 mm; $n = 83$) for *P. flavata* and 1.17 mm (range: 1.05–1.29 mm; mode: 1.18 mm; $n = 23$) for *P. gentilis*. Fifth-instar larvae of *P. flavata* have a mean head width of 1.84 mm (range: 1.68–2.06 mm; mode: 1.84 mm; $n = 121$) while those of *P. gentilis* have a mean head width of 1.65 mm (range: 1.58–1.87 mm; mode: 1.71 mm; $n = 30$). Identification of second-instar *P. flavata* was tenuous at best. Second-instar identification of *P. gentilis* was more dependable because of the obvious lack of a dorsal spacing hump. Mean head width for second-instar *P. gentilis* larvae is .47 mm (range: .45–.52mm; mode: .48 mm; $n = 32$). No first-instar larvae could be positively identified for either species. Results indicate that larvae of *P. flavata* may begin to reach fifth (final) instar as early as October, with a large number of fifth-instar larvae occurring by December and January. In *P. gentilis*, on the other hand, although second- and third-instar larvae were collected in late November, no fifth-instar larvae were evident until March[1]. This agrees with the findings of Mackay (1972) which is surprising considering the difference in the latitude of the populations studied.

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[1] The fifth-instar of *P. gentilis* may have been reached as early as February; however, weather conditions did not permit collection of a sample in February.

Diapause and pupation.—A number of larvae of both species attain final instar as early as five or six months before pupation and adult eclosion. This suggests some sort of resting period such as has been reported for other species of *Pycnopsyche* (Wiggins, 1977; Mackay, 1972; Cummins, 1964). Present data do not allow distinction between a period of reduced larval activity or true physiological diapause.

The larvae of *P. flavata* do not appear to seal the front of their cases with small stones much in advance of the actual time of pupation. Sealed cases are evident only infrequently before June. Placement of an anterior sieve plate appears to occur just prior to pupation. Larvae with sealed cases but no anterior sieve plate often re-emerge when disturbed.

Prior to their resting period and subsequent pupation the larvae of both *P. gentilis* and *P. flavata* may anchor their cases to either larger stones or, occasionally, pieces of wood. In some instances a number of smaller stones may be attached to the front of the case to serve as an anchor.

Adult emergence.—Available records for emergence of *P. flavata* adults range from May 18 in Virginia (C. R. Parker, personal communication) to October 2 in North Carolina (G. B. Wiggins, personal communication). Southern Appalachian *P. gentilis* emerge later with records ranging from August 12 to October 30 in Virginia (C. R. Parker, personal communication). The majority of records, however, indicate that most *P. flavata* emerge from early May to late August, while most *P. gentilis* from comparable latitudes emerge in September and October. The virtual lack of overlap between the adult flights of the two sympatrically occurring species probably serves as a reproductive isolating mechanism leading to later hatching and development of *P. gentilis* larvae which limits competition between comparable instars of both species.

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